BIOSPHERIC TRAUMAS CAUSED BY LARGE IMPACTS AND PREDICTED RELICS IN THE SEDIMENTARY RECORD: R.G. Prinn and B. Fegley, Jr., Dept. of Earth, Atmospheric and Planetary Sciences, MIT, Cambridge, MA 02139

When a large asteroid or comet impacts the Earth the supersonic plume ejected on impact causes severe shock heating and chemical reprocessing ($N_2 + O_2 \rightarrow 2NO$) of the proximal atmosphere. The resultant NO is converted rapidly to $NO_2$ ($2NO + O_2 \rightarrow 2NO_2$) which over time scales of months to years disperses over the globe and is converted to concentrated nitric and nitrous acids. For sufficiently energetic impactors (e.g., a large new comet) the resultant acid rain is global in extent with a pH $\approx 0$ to 1.5 (1).

Environmental effects of these chemical processes include inhibition of photosynthesis due to extinction of solar radiation by $NO_2$, foliage damage due to exposure to $NO_2$ and $HNO_3$, toxicosis resulting from massive mobilization of soil trace metals, and faunal asphyxiation due to exposure to $NO_2$. The acid rain decreases the pH of the mixed layer of the oceans sufficiently to destabilize calcite thus traumatizing calcareous-shelled marine organisms and inducing massive exhalation of $CO_2$ from the mixed layer into the atmosphere. The global warming due to this $CO_2$ injection may last millenia due to the extinction of ocean organisms which normally aid removal of $CO_2$ from the atmosphere-mixed layer system through their sedimentation.

One class of relic evidence for the above effects arises because extinction of species caused by these chemically induced traumas would be selective. In particular, many plants will survive in dormant and seed stages, silicaceous upper ocean organisms will be less susceptible to pH decreases than calcareous ones, and organisms in the deeper layers of the ocean will be insulated from the worst of the chemical invasions. Also, freshwater and burrowing organisms could survive because a not insignificant fraction of the worlds lakes and soils will be effectively buffered (by carbonates, etc.) against acid invasions.

A second class of relic evidence arises because the acid rain will cause massive weathering of continental rocks and soils characterized by large ratios of the relatively insoluble metals (e.g., $Be^{2+}$, $Al^{3+}$, $Hg^{2+}$, $Cu^{+}$, $Fe^{2+}$, $Fe^{3+}$, $Tl^{3+}$, $Pb^{2+}$, $Cd^{2+}$, $Mn^{2+}$, $Sr^{2+}$), to the more soluble metals ($Ca^{2+}$, $Mg^{2+}$). This weathering would be best recorded in fossils in unperturbed deltaic, neritic, or limnetic sediments and for metals with very long oceanic residence times (e.g., $Sr^{2+}$) in deep ocean sediments as well.

Of particular interest is the geochemical evidence for a large impact and associated dust clouds and wild fires at the end of the Cretaceous (2, 3). While these dust clouds and wild fires are not themselves potent global extinction mechanisms, the chemical effects discussed above are and may serve to explain the extensive extinctions at the Cretaceous-Tertiary boundary. In particular, several of the predicted relics of these chemical events are evident in the sediments at this boundary. We regard this as further evidence for impacts at this time and more specifically for one or more massive energetic cometary impacts with their associated production of nitrogen oxides and acid rain. The most important evidence for this *"acid rain"* hypothesis is provided by a recent analysis of the $^{87}Sr/^{86}Sr$ ratio in foraminifers in cores from the Deep Sea Drilling Project which indicate a sharp positive spike in this ratio at the Cretaceous-Tertiary boundary. This spike seems explicable only by massive and sudden weathering of the $^{87}Sr$-rich continental silicates which requires acidic rain with pH $\leq 2$ (4).

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